DAWN E/PO GUIDE

Vesta Arrival

August 19-20, 2010 | UCLA | Los Angeles, CA

Table of Contents

***New page numbering system after Appendix 1**

MISSION BACKGROUND AND OVERVIEW

The Dawn Mission will characterize the conditions and processes of the solar system's earliest epoch by investigating Vesta and Ceres. These two protoplanets are the largest among many smaller bodies residing in the main asteroid belt, an extensive zone between Mars and Jupiter. Vesta is located toward the inner region of the asteroid belt and Ceres toward the outer region; they followed very different evolutionary paths, constrained by the diversity of processes that operated during the first few million years of solar system evolution.

The Dawn Mission extends exploration of the solar system while offering context for other NASA endeavors. Dawn will provide data on the role of body size and the presence of water in planetary evolution and form a bridge between the investigation of the rocky inner solar system and the icy outer solar system. Dawn's journey will complete the first order exploration of the inner solar system, addressing NASA's goal of understanding the origin and evolution of the solar system, providing context for understanding extra solar-planetary system observation, and complementing ongoing investigations of Mercury, Earth and Mars.

As such, Dawn's Education and Public Outreach has had the opportunity to leverage and build upon E/PO efforts made during previous NASA missions. Rapid multimedia and technological advances offer unsurpassed opportunities to reach a larger and more diverse audience, while developing new materials that promote NASA's cutting-edge science and engineering to classrooms and the general public.

History

During mission phase A, Dawn's principal investigator was very clear in his directions for Education and Public Outreach: the E/PO materials were to be of the highest quality and utility. We had a pledge from the PI for close collaboration with the science team and level funding for the duration of the mission. To galvanize Dawn's E/PO objectives, the team partnered with Mid-continent Research for Education and Learning (McREL), a leader in standards-based research and evaluation-backed curriculum and professional development with previous NASA E/PO experience. McREL's resources include expert personnel and associations with schools and districts over a wide demographic range and geographical area. In addition to working with McREL, the E/PO team contracted with Magnolia Consulting to conduct formal reviews and evaluation of the E/PO process and materials so that subsequent E/PO groups could benefit from lessons learned.

From the beginning, the E/PO plan focused its efforts on creating products that help students, faculty, and the general public understand the Dawn mission and share in the anticipation and expectation of Dawn's arrival at Vesta and Ceres. Leveraging existing government-funded educational tools and practices is a high priority – ranging from *National Science Education Standards* to previous NASA education and public outreach efforts. Students starting in the 7th grade at launch would be in their sophomore year of high school by arrival at Vesta, and in their sophomore year of college by arrival at Ceres. The length of Dawn's mission offers an uncommon opportunity for E/PO to develop comprehensive content modules and activities that

introduce the E/PO audience to the knowledge and insight of the science team and those working in the field of solar system origins. In this way, the public can "participate" in the mission as it unfolds.

Dawn E/PO has taken advantage of evolving technologies, promoting web-delivered material and interactive, flexible mission-related products. For example, although each content module is a two-to-three week classroom content module, individual lessons can be implemented as stand-alone activities in classes or informal settings. Our modules' interactive components help students develop conceptual understanding and are highly engaging. This variety of resources allows diverse audiences to access our materials: the Explorer Guide (for independent learners), the Teacher Guide (for classroom teachers), and the Leader Guide (for informal learning settings). In this way, we are able to disseminate our products in various venues and to a wide range of audiences.

Finally, to direct our work over each phase of the mission, the E/PO team is producing the Dawn Guide. The Dawn E/PO Guide chronicles the E/PO efforts over the years of the mission, along with our regular evaluation reports, will serve as a resource for many NASA mission education and public outreach initiatives in the future. The Vesta Arrival Guide is included here.

Overview of Principles:

For students and the general public, the Dawn mission presents a unique opportunity for "time-travel": a chance to travel back in time to view solar system material as it existed before planetary formation. By participating in this discovery and sharing the existing knowledge available to the science community, students and the public will also share in the expectation and anticipation of Dawn's arrival at Vesta.

Dawn E/PO has been distributing Dawn E/PO materials since 2004. Students in the 7th grade at that time, now freshmen in college, have followed the development of the Dawn mission into early adulthood using our formal, informal, and independent learning tools and activities. Because of this broad dissemination over time a knowledgeable general public will be prepared to view the initial images and data from Vesta with understanding and pride in NASA's accomplishment.

Over the duration of our mission, we expect large numbers of students and the general population to come to our website to learn outside of traditional settings. Therefore, we feel that all deliverables should be accessible to formal, informal, and independent learners. All of our materials include teacher/leader guide materials and also exploration guides designed for independent learners. Mid-Continent Research for Education (McREL) and Learning in Denver, CO and the Center for Effective Learning at New Roads School, Santa Monica, CA have been researching what is known about independent learner guides.

E/PO Management Team Responsibilities:

The Dawn E/PO team reports to the Principal Investigator, Chris Russell. The team of J. Wise (E/PO manager), and John Ristvey, Judy Counley, and Whitney Cobb of McREL has worked very well. Each brings complementary strengths to the team.

L. McFadden: Former E/PO Director, University of Maryland

- Responsible for Dawn E/PO Program
- Science Team Liaison
- Transferred to a new position at NASA Goddard Space Flight Center in 2010

J. Wise: E/PO Manager, Center for Effective Learning, New Roads School

- Responsible for day-to-day management
- Provides focused direction for the E/PO team and contributors
- Serves as coordinator for all Dawn E/PO activities
- Combines science with innovative curricular ideas
- Provides curricular content and review
- Coordinates mission team review and input for EPO materials
- Maintains contact with NASA Small Bodies Forum
- Reports to mission PI and JPL Project Manager

McREL: J. Ristvey, J. Counley, W. Cobb, N. Hess, D. Bogner, M. Cullen

- Responsible for website, content development, pilot and field testing, communication, evaluation, dissemination
- Provides NASA E/PO experience
- Provides expert insight into working on Discovery Program and mission E/PO from over 12 years of NASA/JPL experience and access to networks gained from over 40 years of serving the formal and informal education community
- Tasked by the US Department of Education to do research in curricular development
- Provides expertise in educational standards and classroom practice

Evaluation Team

Magnolia Consulting: Dr. Stephanie Baird-Wilkerson, Carol Haden

- Responsible for external evaluation
- Evaluation design and implementation (formative, summative)

Identified Topics for Educational Components:

The following mission-related topics have formal/informal educational value. (CM = Content Module)

Asteroid Belt
- Discovery – CM 1
- History – CM 1
- Relevance – CM 4

Ground-based astronomical observations of asteroids

- Telescopic Data – AOP
- Photometry – AOP
- Astrometry – AOP

Role of Meteorites
- Return samples – FAM
- Composition – FAM

Role of Cratering
- Surface process – Clickworkers
- Surface age – Clickworkers

Role of Light Curves
- Rotational period – Potato Light Curve Activity
- Object shape – CM 4; in development

Space exploration
- Engineering design – CM 2
- Ion Propulsion – Ion Propulsion Simulation
- Navigation – Where is Dawn?

Instrumentation
- Gravitation – CM 3, Interactive in development at JPL
- Composition – VIR and GRaND interactive; CM 3
- Surface Features – FC interactive in development

Data analysis – CM 5 planned for cruise between Vesta and Ceres

These educational components are delivered to our audiences through Exploration Tools and Activities and/or as content modules.

Content modules address the "Asteroid Belt," "Space exploration," "Instrumentation," and "Data analysis."

Unique Opportunities

- 2006 IAU definition of planet – Ceres and Pluto (Dwarf Planet activity)
- Arrival at Vesta coincides with NASA SMD Year of the Solar System with planetary missions with significant mission events
- During arrival potential use of social networking for public engagement updates
- Unlike many NASA missions, data from a target body (Vesta) is available to the E/PO team during a funded part of the mission in order to develop education products/services during the two years of cruise to Ceres

Materials Development Cycle:

Figure 1 illustrates our product development plan.

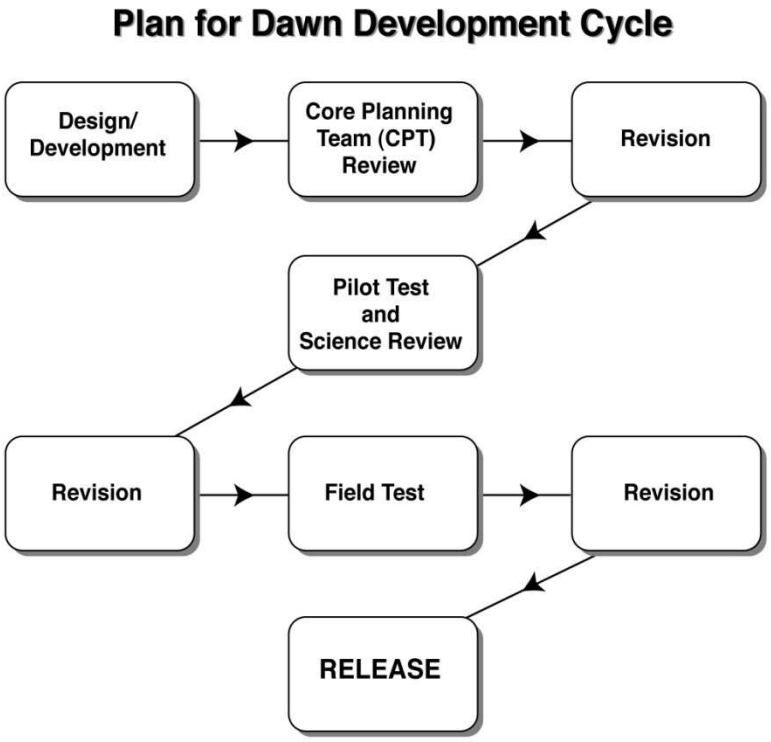


Figure 1

A. Design/development
   - E/PO team collaborates with colleagues in the informal and formal education communities to develop a draft of the deliverable. Science review by appropriate mission team members, educational review by J. Wise, and McREL internal quality assurance, evaluation plan designed by Magnolia Consulting LLC.

B. Core Planning Team (CPT) Review
   - The CPT is made up of a diverse collection of formal and informal education professionals who review our materials before pilot testing. This review assures that we are creating materials appropriate for a widespread audience.
   - Dawn E/PO materials are planned (during specification/outline review and draft review) prior to pilot testing to include content and strategies to best meet the needs of diverse learners. The development process incorporates research and best practice from McREL's Diversity Roundtable and literature on differentiated instruction. Future QA will include review by a McREL internal diversity expert for cultural sensitivity.
   - The Dawn E/PO has developed a cost-effective method of acquiring formal and informal educator feedback on the materials under development. By using the existing state and national professional conferences, the E/PO team is able to present our materials to a large, representative group of educators without a need to pay for travel and housing.

C. Revision
   - Revisions will be made using feedback from the CPT review.

D. Pilot test and science review
   - The pilot test is conducted with a limited sampling group of participants and is intended to identify any logistical problems that might occur in formal and informal settings. Our original concept study plan included testing Dawn E/PO materials with teachers in McREL's development network; at the time, this group included educators from Haskell Indian Nations University (Kansas), LA county public schools, and teachers associated with the CAPS program, which is sponsored in part by the National Organization of Black Chemists and Chemical Engineers. Although these groups signed letters of agreement, they did not ultimately participate in pilot testing. As a result, we recruited from other organizations. During the pilot tests we acquire information on participant ethnicity.
   - During this stage, we submit our product to the Dawn Science Team and NASA/JPL for review. This review helps identify any potential problems prior to releasing the product, allowing for sufficient time to make revisions and/or changes.

E. Revision
   - Revision is carried out using feedback from pilot teachers/students and NASA/JPL/Science Team.

F. Field test
   - The field test is a much broader test of our materials. Here we draw on McREL's extensive, national network of formal and informal educators as potential reviewers. Materials are delivered to teachers, museum curators, etc. to test for effectiveness and usability. In this way, we can be confident that we're providing materials and delivery mechanisms that meet the needs of a diverse audience.

G. Revision
   - Revision is done based on the feedback from the field testing. Submitted to NASA Product Review (consisting of panel of educators and scientists)

H. Release
   - Through websites, and conferences, webinars and formal/informal presentations

Dissemination:

The Dawn mission print products are broadly disseminated using multiple venues that are presently in place through NASA's Web, conferences, and other dissemination platforms. The mission E/PO registers print products in NASA's product registry online, thereby heightening awareness of and public access to these items. All products are submitted through the annual product review process through NASA's Science Mission Directorate (SMD), formerly the Office of Space Science, for review, feedback, and dissemination and training opportunities for NASA's Resource Centers and AESP programs. Likewise, E/PO will identify items that can be disseminated through NASA CORE.

The following Dawn EPO materials have been reviewed and accepted by NASA:

- Modeling Asteroids in 3-D Exploration Guide (from CM 1)
- Vegetable Light Curves (from CM 1)
- Ion Propulsion (CM 2)
- Asters Hoity Toity Belt

- Dwarf Planet Activity
- Find a Meteorite

Content Modules:

The Content Modules are designed for delivery in formal, informal, and independent learner environments. Content Modules are key to the effective delivery of the formal and informal educational components of the Dawn E/PO materials. All of the E/PO components are available as stand-alone activities, but are most effective when linked to a Content Module via hyperlinks and curricular material. Content Modules which are mapped to national standards form the framework for placing E/PO activities and tools into formal and informal educational settings.

Our mission supports the SMD/SSE goal of addressing "where did we come from." As such, we intend to develop a corresponding content module, complete with visualizations/animations for all of our audiences, including museums and science centers. We will use planned and existing materials from other NASA missions to demonstrate the complementary nature of these missions and how the process of scientific exploration is actually conducted. In this way, we can present theories on solar system origins in the context of past and future NASA missions and activities. Our plan for module development is:

1. History of Asteroid Discovery
2. Ion Propulsion
3. Mission Instrumentation
4. Solar System Origins, Theories
5. Data Analysis, Anticipation and Expectation

Learning Tools

We initially identified three emerging educational tools to enhance our E/PO products. Calibrated Peer Review (CPR) is a web-based program intended to improve writing and critical thinking skills. Although our own tests of the program confirmed its potential to enhance our products, the need to conduct training and development in this tool for widespread use is beyond the scope of our efforts. We hope to return to this tool during the cruise period between Vesta and Ceres.

An Interactive Multi-Media Exercises (IMMEX) tool, currently in use for science problem-solving from K-12 through post-secondary curricula, is another tool that holds promise for use with our products. During cruise phase between Vesta and Ceres, we will explore the possibility of providing materials to formal and informal educators at IMMEX workshops, which will be leveraged to develop exercises that are incorporated into our content modules and other materials as appropriate.

We have had several meetings regarding the development of The Perceptual Learning Module (PLM) with experts at UCLA. Perceptual Learning Modules can make basic concepts and patterns intuitive to students and provide online assessment of students' progress, allow learning to proceed to set criteria, and readily support objective tests of transfer to other tasks. A PLM on surface features is feasible for this project. We will continue to pursue the development of this

tool during cruise between Vesta and Ceres by submitting additional proposals to NSF and NASA to help support this activity.

The Dawn Learning Cycle

All of our materials are developed using the five-step learning cycle initially used by McREL for the NASA Discovery mission Genesis. This learning cycle structure is flexible and dynamic.

1. Briefing – Introduces multi-disciplinary modules emphasizing science and technology content.
   - capture student attention and engagement (texts, questions)
   - introduction (build upon prior knowledge)
2. Exploration – Introduces students to new ideas through activities, links these ideas to students' current understandings, and stimulates new questions that lead to learning. Activities may include reading, hands-on activities, discussions, manipulation of data, or exploration of resources.
   - Information gathering
   - 1-3 student activities
   - Online searches/journals/texts/interviews
3. Development – Instructs through experiments, observations, or reading and discussion of text. After data are recorded and interpreted and conclusions are drawn, a relationship between evidence and decision-making emerges. Technical vocabulary may be introduced here. Students may use mathematics and computer tools in their work.
   - begin to develop an idea in a context through asking questions
   - move explorations findings forward
     1. Construct meaning around prior knowledge, mix with exploration and develop new context
     2. Result: new questions, e.g., Why Vesta?
4. Interaction and Synthesis – Encourages interactions with peers or appropriate resource persons to accomplish a task. This phase of the cycle may include two types of communication:
   - Communication Design – students design methods for communicating observations, results, and conclusions to a target audience.
   - Debate – Students deliberate and consider opposing points of view. Discussions center on a given proposition regarding the Dawn mission or related science.

   Additionally, students should maintain a laboratory notebook. This can serve as a medium of communication between teachers and students, as well as an avenue for assessment.
5. Assessment – Allows students several options to demonstrate what they've learned. The goal is to determine student achievement relative to standards addressed in the module. Assessment items may be selected or constructed by the teacher.

Core Planning Team (CPT):
The CPT is made up of a diverse collection of formal and informal education professionals who review our materials prior to pilot testing. This review assures that we are creating materials that are appropriate to a widespread audience. The structure of the CPT has changed from our preliminary proposal, although its function remains the same. Initially, we had intended to select CPT members from middle schools, high schools, media, etc., to meet with us to review materials to ensure that we were serving the needs of the community. However, we discovered that this structure carries some hefty costs in travel, stipends, and room/board. After reviewing several options, we decided to leverage various professional, state and national conferences to involve both formal and informal educators in reviewing our materials.

Dawn Planning Guide:
The Dawn Planning Guide is developed for each phase; collectively, these guides constitute our E/PO Plan. The plan lays out a specific, phase-by-phase guidelines for the E/PO activities for the life of the Dawn Mission. It guides our statements of work and our evaluation plan, providing the philosophical underpinnings for the decisions that are made both on a long-term and daily basis.

This guide is reviewed by the E/PO Management Team, the Dawn Mission PI, and NASA/JPL E/PO reviewers.

Public Engagement:
Over the duration of the Dawn mission, it is conceivable that more and more learning will be done in an individualized setting via the internet. For this reason, we actively engage the public through exploration guides for the independent learner. These guides provide information for individuals who may not be members of school groups, amateur science groups, or after-school programs, but may simply be interested in small solar system bodies and/or planetary formation.

Our plans for public engagement in the Dawn mission include:

Electronic Newsletter
The Dawn e-newsletter engages the public by communicating current developments in the mission. Our website and visibility efforts ensure access by the public to our E/PO content and learning materials.

Solar System Ambassadors
We are engaging the Solar System Ambassadors program (http://www2.jpl.nasa.gov/ambassador/) for the year of arrival at Vesta to bring mission related information and updates on progress to the public. We have developed a Speakers Kit and will host trainings for Solar System Ambassadors via web conference.

Challenger Centers
Dawn E/PO has provided webinars/updates on small bodies missions via the Challenger Center program http://www.challenger.org/. Most recently, we have discussed incorporating existing

Dawn educational materials into a new mission simulation for national distribution with Rita Karl, director of education for the Challenger Centers.

Informal Education/Museum Exhibits
The general public is most readily engaged in science learning by means of planetarium shows, museum displays, hands-on activities, and after-school programs. Dawn E/PO is working with Anita Sohus and the Museum Alliance to provide training and materials for member organizations.

We have provided Dawn materials for the *Great Balls of Fire* national traveling exhibit funded by NSF and NASA. Dawn E/PO team reviewed a set of hands-on activities developed by the Astronomical Society of the Pacific designed to engage out of school time learners in the science of small bodies such as asteroids and meteorites.

In addition, Dawn provided graphics, fact sheets and materials for the Space Rocks ToolKit and contributed new graphics for the development of the NASA/JPL Community Nights Boards intended to reach rural audiences.

Dawn E/PO has also contributed to the Meteorite Museum at the University of New Mexico http://epswww.unm.edu/meteoritemuseum/index.htm, located in Northrop Hall on the Main Campus. The Museum houses many meteorites from the extensive collection of the Institute of Meteoritics. The highlight of the Museum is a one-ton piece of the stony meteorite, Norton County that fell in Kansas in 1948. The theme of the exhibits is “Looking at the Solar System through a Microscope." The displays show how scientists learn about asteroids, comets, the Moon and Mars by studying samples that have fallen to Earth from space, as well as samples that have been collected by spacecraft missions. The Meteorite Museum has been working with Dawn science team member Tom Prettyman from the Planetary Science Institute. He is interested in developing ways to explain the science behind the GRaND experiment.

The next big community activity for the Meteorite Museum is the Cosmic Carnival, which will be held September 5, 2010 at the Balloon Museum in Albuquerque. University of New Mexico has participated in this activity for several years, which started as an Astronomy Day activity.

JPL Openhouse
Each year Dawn E/PO coordinates the Dawn presence at the JPL Openhouse an annual event that celebrates JPL's accomplishments with exhibits and demonstrations about the Laboratory's ongoing research and space exploration by providing display materials, E-News sign up, and fielding questions reaching tens of thousands of people over two days.

STEMaplooza
Science, Technology, Engineering, and Mathematics (STEM) come together in Denver, Colorado each fall during the STEMapalooza: an all-out party and celebration of science, technology engineering and mathematics fields! Dawn mission E/PO materials are included at a fun and exciting booth where participants have an opportunity to take part in a variety of hands-on, interactive activities.

Out of School Time Conferences and Speaking Engagements
We engage public education professionals and amateur groups (e.g. astronomy clubs, Girl Scouts, Observatories) as members of our CPT by presenting at professional conferences. In this way, we assure that we are meeting these groups' needs for engaging and informative materials. Based on our work with these groups, we have found that these professionals prefer information and support as they develop materials for their specific situations. We will continue to provide this service. All of our delivered material is designed for use by diverse organizations, and includes teacher guides, leader guides, and exploration guides. In addition to providing our materials at conferences, we regularly receive requests for entertaining and educational material from afterschool programs. Our leader guides are designed for program administrators, whereas our teacher guides may be helpful to program teachers. After school programs are requesting material that is entertaining and educational. The leader guides are designed for people running these after-school programs. We have contributed to the NASA presence at the National Afterschool Association annual conference.

*Mission Status Updates*Each month the mission's Chief Engineer, Marc Rayman from JPL, provides a short update on the mission status, which is delivered via the mission section of the website and the e-newsletter.

Dawn Journal
In addition to the mission status update, Marc Rayman contributes a monthly Dawn journal, which provides an engaging insider's look into interesting aspects of the mission. We are providing Spanish translations of the Dawn journal as a test for engaging a more diverse population.

Social Networking
We have included social networking buttons on the current website to allow viewers to share content through a variety of social networking applications. During our 2009 planning meeting at the University of Maryland, the Dawn E/PO team discussed the use of Facebook and Twitter as a means of public engagement. We have made inquiries at NASA and JPL regarding rules and process to ensure we are in compliance with any policies or requirements. Our plan is to include mission status updates and Facebook and Tweet updates from key mission personnel.

Year of the Solar System
NASA's Science Mission Directorate is celebrating the Year of the Solar System (YSS) from October 2010 through September 2012: a Martian year (about 24 Earth Months)! Dawn E/PO is participating with other missions to leverage the numerous exciting launches, events, and returns planned for this timeframe. Members of the Planetary Science Education and Public Outreach Forum (SEPOF) are sharing current plans and anticipated resources.

Evaluation:

The E/PO program and its products undergo extensive informative and summative evaluations. An expert in evaluation is included in the Dawn E/PO management team. This expert makes

sure that every aspect of the E/PO is designed for effective evaluation. Please see page 14 for our complete evaluation plan.

Deliverables:

In anticipation of Dawn's arrival at Vesta, Dawn's EPO continues to develop materials that allow students and the general public to share, with the scientific community, the anticipation and excitement of Dawn's arrival at Vesta, and the resulting data return.

Maintained:

1. Monthly updates of website
2. Monthly e-Newsletter
3. FAQ page
4. Dawn Dictionary
5. Dawn Young Engineer
6. Dawn People page
7. Dawn Media page
8. Where is Dawn
9. Find a Meteorite
10. Ion Propulsion Simulation
11. VIR Simulation
12. GRaND Simulation
13. Content Modules
14. Dawn Journal (Marc Rayman)
15. Mission Updates (Marc Rayman)

Arrival Plan:

1. Picture of the day
2. E-News build up reviewing the Dawn story
3. Educator conferences (Digital Learning Network and Small Bodies, Big Concepts)
4. Presentations at conferences
5. Solar System Ambassadors
6. Students on lab
7. UCLA Extension Professional Development Class
8. Facebook/Twitter/Podcast

Delivery History: (Following from the original EPO Plan)

Content Modules – Completed

- Content Modules 1- 3 are completed
    - History and Discovery of Asteroids
    - Ion Propulsion
    - Instrumentation

Content Modules – To be completed

- Content Module 4 ready for field testing fall of 2011
    - Origins of the Solar System – the story of the Asteroid Belt
- Content Module 5 completed during cruise from Vesta to Ceres
    - Data return

Mission Patch Contest – Completed
The Mission Patch contest became our Dawn Young Engineers Program. Geared mostly toward younger children, people downloaded accurately detailed scale drawings provided by Orbital of the spacecraft. The paper model was assembled and with proper permissions, pictures of the person and his/her spacecraft were uploaded onto the Dawn EPO website. This activity eliminated the need for judging and awarding of certificates etc. Participants could download certificates from the webpage and fill in their names.

Asteroid Book Cover/Poster – Completed and approved
Due to rules concerning the design of posters, the original idea morphed into the Dawn Mission Calendar, complete with mission events, science team photo, mission trajectory, and images of Vesta and Ceres.

Mission Identifier – Completed
The mission identifier for the Dawn mission is the Dawn spacecraft with or without the Hartmann background. The spacecraft image was used by the EPO team as a "mission patch" became a sticker that was given out to students at schools and to people attending JPL Open House.

Solar System Ambassadors – Completed
The Solar System Ambassadors were budgeted into the launch year and arrival years for Vesta and Ceres. Because of their reach and associated costs, this was a very successful venture and well worth the investment.

Website – Completed and ongoing
We are currently completing a major facelift with our web page to bring it into compliance with a new NASA/JPL look and feel. This facelift includes a complete review of navigation and content based on our evaluations and input from Raytheon's web development group. We will have additional bandwidth available around arrival in anticipation of increased web activity.

Electronic Newsletter – Completed and ongoing
The Dawn E-News currently has almost 6,000 subscribers. We have had great success with delivering materials to a focused community of teachers, mentors, and the general public. We are able to time delivery to mission events, teacher events, and the school year. The Newsletter has been very popular at presentations and especially at the JPL Open House.

Find a Meteorite (FAM) – Completed and approved
FAM is a web-based interactive designed to introduce the role that meteorites have played in our initial models of Vesta. Since we developed this as an online interactive tool, schools/museums can participate in this learning experience without the expense of purchasing materials. Students

can “pick up” samples and rotate them, can make observations in order to determine if the sample is a meteorite or an Earth rock via the web.

The University of New Mexico has submitted two proposals for the Bruker - Tracer X-ray fluorescence instrument as part of a list of suggestions for future work. The use of this instrument in outreach to demonstrate a type of atomic spectroscopy was a major justification, and our tests also show it to be useful for determining if a sample is a meteorite or not. The effort of working with the public is ongoing and has substantially ramped up in the last year (2010). There is a need for a more objective way to test samples, and the ability to quickly measure nickel is essential. Dawn E/PO has been in conversations with NASA Johnson Space Center about collaborating on a high school level activity using data from Vesta to link meteorites with parent bodies.

Telescopes in Education (TIE) – Failed
Although project funding for TIE was discontinued, we improvised by leveraging Deep Impact’s Amateur Observer program to provide information and a place to network with other amateurs and space to share images of Vesta and Ceres. This worked quite well and provided opportunities for amateur astronomers to upload images of Vesta. Some work on light curves was also undertaken. We have contacted several remote telescope sites across the country and still may work to develop opportunities for participants to discover new asteroids and/or to plot orbits, and/or explore light curves.

Video – Completed and approved
The video was originally issued as a prelaunch video that introduced the Dawn Mission, its key personnel, and its objectives. It was narrated by Leonard Nimoy and written by D. C. Agle from JPL Media Relations. This project included animation that has been used in numerous places to illustrate key points in the mission. This video was used without Nimoy’s voice in several YouTube uploads. YouTube allowed for a wide distribution of the video without incurring postage costs and bandwidth issues.

Additional money budgeted for the virtual tour initially was used for a suite of instrumentation interactive (Gamma Ray and Neutron Detector, Visible and Infrared Spectrometer, and Framing Camera). These interactives were developed after the success of the ion propulsion simulation. These simulations and interactives have proven themselves as stand-alone products, but have also worked nicely into our content modules and other curricular pieces.

Clickworkers (CW) – Failed to date
The developer had a small window to work with us on its development but unfortunately that window was the same time that Dawn was shut down. After that window, the developer was never able to devote the time necessary to really take advantage of this extraordinary opportunity. Dawn now has the original source code and we will be determining our next steps at our August summative EPO review. We are working with an engineer at Ames who is attempting to keep clickworkers running on servers there and plans to update to a newer programming language. We continue to look for similar pieces of software to replace Clickworkers. The surface study and age of surfaces component of the crater counting activity is of educational value and should be pursued.

Conferences –National, Regional and State Conventions and Conferences
We have attended and presented at numerous state and regional conferences including the National Science Teachers Association (NSTA), etc.

Launch Educator Conference
In the summer of 2007, we convened educators in Florida for a joint educator/science conference. Over the course of three days, educators from around the country learned about mission-specific content and had their questions about solar systems origins and the nature of science answered by scientists from both the Dawn science team and the larger science community. This conference included:

- Hands-on activities linked to standards
- Tours of Kennedy Space Center (KSC)
- Joint sessions (plenary and posters) with science team and invited scientists
- Science team member presentations on aspects of mission
- Joint sessions with parallel conference at Wheeling West Virginia via NASA Broker Facilitators
- Night sky observing of Vesta
- Presentation and tours at NASA KSC Educator Resource Center
- Podcasts of proceedings were edited and disseminated via Dawn website

Webinars – Dr. McFadden in Antarctica
The Dawn EPO team used web 2.0 resources to broadcast a presentation by Dr. McFadden on her trip to find meteorites in Antarctica. Throughout the webinar, over 100 participants were tuned in via the webinar.

Mars Flyby Educator Conference
Based on the success of Dr. McFadden's webinar, we leveraged the Mars flyby event in February, 2009 to provide updates to educators at four locations in three time zones. The Mars Flyby Educator conferences:

- Were held in four locations: NASA JPL (Pasadena CA), Oregon Museum of Science and Industry (Portland OR), Denver Public Schools (Denver CO), NASA IV, V ERC (West Virginia)
- Utilized NASA Digital Learning Network
- Included local tours and opportunities at each location
- Provided simulcast of Science Team Presentations
- Leveraged AESP facilitator

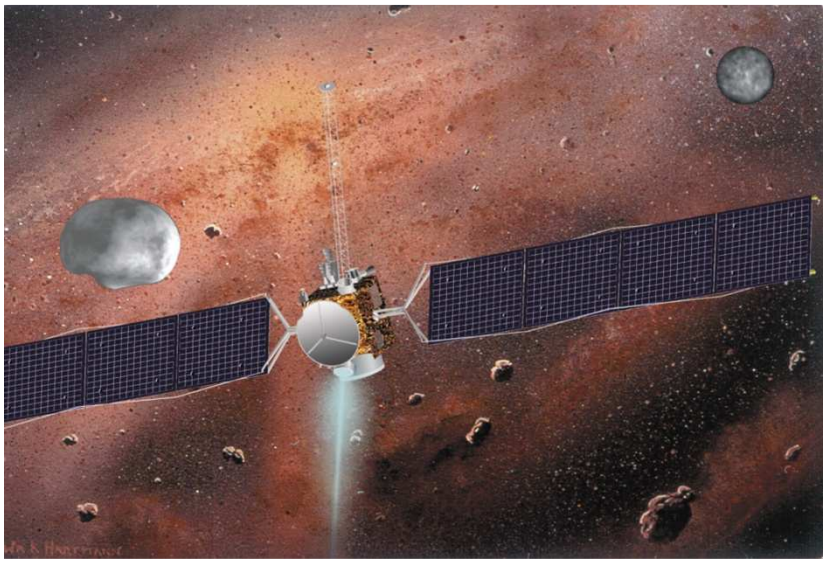
This professional development opportunity is based on research suggesting that local PD provides networking that encourages continued use of national and community-based resources. The local venues benefited from the workshops by receiving Dawn materials and training, and also through creating awareness about their existing programming for interested educators. This activity was highly successful and will serve as a model for activities around arrival.

Collaborations
To date, we have collaborated with NASA ERC's, AESP, Girl Scouts, Boys and Girls Clubs, Planetary Science Education and Public Outreach Forum, LPI, Challenger Centers and with proposed future missions E/PO lead to small bodies.

Evaluation – Magnolia Consulting LLC
The formative and summative evaluations of products and the EPO plan have been ongoing with reports published from 2004-2009. These formative evaluation reports can be found at: http://dawn.jpl.nasa.gov/education/index.asp. Dawn's EPO will undergo a summative review August, 2010 in anticipation of arrival at Vesta.

Appendix 1
Dawn Mission Education and Public Outreach

Evaluation Plan



Submitted to:

Dawn E/PO Team

Submitted by:

Stephanie Baird Wilkerson, Ph.D.
Mid-continent Research for Education and Learning
Aurora, CO 80014

September 17, 2003

McREL

Cover credit: Background painting, "A cocoon nebula, perhaps the primoridal solar nebula" by William K. Hartmann. Courtesy of UCLA

TABLE OF CONTENTS

TABLES

INTRODUCTION

As part of its Discovery Program, NASA awarded funding for the Dawn mission in December 2001. Dawn, the first mission to the Main Asteroid Belt, will investigate Vesta, one of the largest protoplanets remaining intact since its formations. The mission will address the role of size and water in determining the evolution of the planets by measuring mass, shape, volume, and spin rate with imagery, laser altimetry, and gravity. Through this investigation, scientists aim to characterize the conditions and processes of the solar system's earliest epoch.[1] The Dawn mission offers a variety of information and data for the public and educators:

> It [Dawn] brings images of varied landscapes on previously unseen worlds to the public including mountains, canyons, craters, lava flows, polar caps, and, possibly ancient lakebeds, streambeds, and gullies. Students can follow the mission over an entire K-12 experience as the mission is built, cruises to Vesta, and returns data.[2]

Dawn begins its trek with a launch in 2006. The craft will travel four years before it reaches Vesta and another three years to reach Ceres with a return targeted for 2015.

The Dawn Education and Public Outreach Initiative

Dawn E/PO consists of a national team of Education and Public Outreach (E/PO) specialists from the University of Maryland, New Roads Schools (CA), and Mid-continent Research for Education and Learning that will develop and disseminate high quality educational resources and materials in support of the Dawn Mission. Dawn E/PO delivers emerging technology and scientific knowledge to the public and to classroom teachers and students. Through the Dawn E/PO Web site, students and the public engage in age-appropriate mission activities, for example, analyzing images for cratering, doing photometry on images to produce light curves, and discussing with mission scientists the importance of Vesta to our understanding of solar system origins. Further participation includes searching for meteorites that may contribute to the mission. Dawn E/PO concurrently uses innovative, educational tools to encourage student collaboration, visualization, and peer-review in ways that conform to and further define the national standards in math and science education.[3]
The E/PO effort aims to enhance educator, student and public engagement in space science through the following overarching efforts:

1. Developing products and activities that reflect "best practices" in education (i.e., standards-driven, pedagogically appropriate, and designed to meet the needs of all students, including disadvantaged and underserved).

---

[1] Dawn: A Journey to the Beginning of the Solar System (2002). The online site for the Dawn mission. Retrieved from the World Wide Web, June 5, 2003, http://www-ssc.igpp.ucla.edu/dawn/.

[2] Dawn Web site: http://www-ssc.igpp.ucla.edu/dawn/

[3] Excerpt from the Dawn Mission E/PO final proposal, July 21, 2000.

2. Developing and enhancing practical and technologically efficient systems for reaching, communicating with, and disseminating products and services to educators and the public.
3. Leveraging resources and maximizing reach by establishing a broad range of working partnerships between related projects and groups.

Dawn's target audiences include a.) educators (teachers and students, K - Post Secondary); b.) general public members (businesses, parents, politicians, and retired); c.) media journalists (national and local, broadcast, print, trade publications, Internet, instructional TV, radio and public service announcements); d.) informal educators (science museums/centers, arts community, speakers bureaus, youth programs, and service clubs); and e.) disadvantaged and underserved populations.

The Dawn E/PO team employs a strategic outreach approach, developed by Mid-continent Research for Education and Learning (McREL) and proven effective in the Genesis mission outreach, which supports NASA's vision and the Dawn E/PO goals. This approach is based on four components: Delivery, Communication, Education Development, and Evaluation. In conceptualizing its work based on the four components of the outreach model, the E/PO team identified eight, long-term ultimate outcomes, which are supported by 17 intermediate outcomes. Logic models were created to illustrate the activities, intermediate outcomes, data collection methods, and ultimate outcomes for each component (refer to Appendix A). The following lists the eight ultimate outcomes:

Delivery and Communication[4]

1. E/PO efforts reach broad target audiences through high quality products and dissemination mechanisms. Primary contacts share what they learn about the Dawn mission and associated science with their colleagues.

Education Development

2. As a result of the knowledge and skills obtained from Dawn E/PO products and activities, participants have a better understanding of the formation of the solar system.
3. As a result of using Dawn E/PO products and activities, participants are interested in solar-system science.
4. Students will conduct science within a real-life context leading to increased academic achievement.
5. Educators have a better understanding of how to implement inquiry processes leading to improved practices.

Evaluation

6. Dawn E/PO products and services are of high quality and utility because they reflect audience needs.

[4] Although the Delivery and Communication components are separate, they support the same ultimate outcome.

7. Dawn E/PO can demonstrate the effectiveness of its outreach as evidenced by the impacts of its high quality products and activities.

8. Future mission E/PO efforts will have a blueprint from which to make informed decisions based on extensive documentation of lessons learned from Dawn E/PO.

EVALUATION APPROACH

The evaluation emphasizes a collaborative approach to evaluation, which requires the active participation of key stakeholders in the design and implementation of the evaluation work. Throughout the evaluation process the evaluator will consider the multiple perspectives held by various project participants.

Role of Stakeholders

The key stakeholders for this evaluation include Dawn E/PO team members, mission representatives, members of the E/PO Core Planning team[5], and project participants including formal and informal educators. By involving stakeholders in the evaluation process, it is intended that evaluation information will be more relevant and meaningful to them. Stakeholders are expected to contribute to the evaluation by informing the evaluation design, providing access to data sources, maintaining appropriate evaluation records, and participating in data collection and data interpretation.

Role of the Evaluator

A lead McREL evaluator is providing independent evaluation services for the E/PO effort and has the collaborative support of the McREL evaluation team. This evaluator is responsible for developing an evaluation plan, designing data collection instruments, collecting data, managing and analyzing data, and meeting reporting requirements and schedules. Because of the participatory approach to evaluation, the evaluator will engage stakeholders in the evaluation process as appropriate. The evaluator will assess the progress of E/PO efforts; provide relevant, timely and meaningful evaluation information; provide formative feedback to guide project development and implementation; inform project-related decision making as needed; and assess the extent to which activities remain aligned with and work towards realizing project goals. An external evaluator from Inverness Research Associates conducts a quality assurance review of the evaluation plan and design, oversees evaluation implementation, and reviews data interpretation and reporting, as necessary.

METHODS

Quality assurance and evaluation are integral to Dawn E/PO product development and service delivery. Both processes ensure that E/PO products and services are of high quality and utility.

[5] The Core Planning Team (CPT) was established in order to review outreach plans, make suggestions for the development of new outreach materials, and provide feedback regarding the perceived utilization of outreach products in a wide range of settings. Team members include representatives from audiences in formal and informal education. Dawn E/PO personnel meet with CPT members during state, regional, and national conferences as well as electronically.

External and internal reviewers participate in the quality assurance process and provide critical feedback during both the design and development phases of E/PO work. This process assures that outreach work adheres to high technical and conceptual standards of quality, is designed to meet identified needs, and is appropriate for target audiences.
The evaluation design includes both qualitative and quantitative methodologies in order to provide formative and summative information. Formative evaluation information provides feedback to project staff, which is intended to guide project planning and development, and allows for a continuous reflective process throughout project implementation. Summative evaluation information addresses the progress made toward intended outcomes of the outreach effort with a description of how the desired outcomes were realized. Furthermore, logic models are used as a tool for defining and depicting how project activities connect to project intermediate and ultimate outcomes.

Evaluation Matrix

The evaluation matrix displayed in Table 1 delineates the components guiding the evaluation process. There are seven key evaluation questions, which link to E/PO intended project outcomes and are supported by additional evaluation questions, information sources, and data collection methods. For each question, the sources to be used in obtaining information and the data collection methods are identified. The following key evaluation questions focus on impacts of the outreach initiative on the public, teachers, and students, as well as the quality and utility of materials and resources.

1. Do users of the Dawn E/PO materials and resources perceive them to be of high quality and utility?
2. To what extent do teachers and students access and use the Dawn E/PO materials and resources?
3. To what extent do public members access and use the Dawn E/PO materials?
4. Are participating students engaged and interested in the Dawn mission science as a result of using E/PO materials?
5. Do participating students have an increased understanding of the formation of the solar system?
6. To what extent has the Dawn E/PO effort enhanced participating teachers' capacity to teach space science?
7. To what extent has the Dawn E/PO effort affected public interest in and understanding of the Dawn mission?

Information Sources

The evaluator has identified multiple information sources in order to answer the evaluation questions. Data will be collected from on-line users of the Dawn Web site, professional development participants, teachers and students in pilot- and field-test sites, and possibly participants in informal education settings, such as museums or science centers.

Data Collection and Analysis

A variety of data collection methods are planned. In some cases, more than one method will be used to address a given evaluation question in order to strengthen the credibility of the findings. Both qualitative and quantitative data will be collected and analyzed. Evaluation data will include information from project documents, online and paper-based surveys, interviews with project participants, observations during site visits, and student assessments. The field-test component of the evaluation will include a quasi-experimental design with pre- and post-test assessments of treatment and non-equivalent comparison groups. This design is employed in order to assess the impact of the Dawn E/PO curriculum materials on student learning.
E/PO team members will have the opportunity to review the interpretation of the information that they provide in interviews and project reports. This process (member checking) verifies that the evaluator has not misrepresented nor misunderstood the perspectives and meanings held by project participants. A database will be created to conduct retrieval, coding, and management of the data corpus for both qualitative and quantitative analyses.

Table 1: Evaluation Matrix

EVALUATION QUESTIONS	DATA SOURCES	DATA METHODS
Ultimate Outcomes #1 & #6: E/PO efforts reach broad target audiences through high quality products and dissemination mechanisms. Dawn E/PO products and services are of high quality and utility because they reflect audience needs.		
Objective 1: To increase the availability of E/PO products and services related to the Dawn mission.		
1. Do users of the Dawn E/PO materials and resources perceive them to be of high quality and utility? 2. To what extent do teachers and students access and use the Dawn E/PO materials and resources? 3. To what extent do public members access and use the Dawn E/PO materials?	Internal and external reviewers Web site users Workshop participants Teachers Students Public members	Quality assurance process On-line surveys Participant feedback Web statistics Dissemination data
Student Ultimate Outcomes #2, #3 & #4: As a result of the knowledge and skills obtained from Dawn E/PO products and activities, participants have a better understanding of the formation of the solar system. As a result of using Dawn E/PO products and activities, participants are interested in solar-system science. Students will conduct science within a real-life context leading to increased academic achievement.		
Objective 2: To increase student awareness, interest, and understanding of space science.		
4. a. Are participating students engaged and interested in the Dawn mission science as a result of using E/PO materials? b. Do participating students have an awareness of and interest in space-related careers as a result of the Dawn E/PO materials? 5. a. Do participating students have an increased understanding of the formation of the solar system? b. Do participating students using Dawn E/PO materials perform better than non-participants?	Students in pilot- and field-test sites Students who access online resources	Pre/post student performance data with non-equivalent comparison groups Student survey (print/online) Teacher reports
Educator Ultimate Outcomes #1 & #5: Educators have a better understanding of how to implement inquiry processes leading to improved practices. Primary contacts share what they learn about the Dawn mission and associated science with their colleagues.		
Objective 3: To increase teachers' use of hands-on, inquiry-based educational materials related to the Dawn mission.		
6. To what extent has the Dawn E/PO effort enhanced participating teachers' capacity to teach space science?	Teachers in development networks Participants in workshops Teachers accessing Web site	Pre/post assessment of capacity Participant evaluations

	resources	Web-based surveys
Public Ultimate Outcomes #2 & #3: As a result of the knowledge and skills obtained from Dawn E/PO products and activities, participants have a better understanding of the formation of the solar system. As a result of using Dawn E/PO products and activities, participants are interested in solar-system science.		
Objective 4: To increase public interest in and understanding of the Dawn mission.		
7. To what extent has the Dawn E/PO effort affected public interest in and understanding of the Dawn mission?	Public members accessing Web site or museum resources	Web-based surveys

WORK PLAN

The work plan describes the major evaluation tasks to be undertaken and their schedule. It should be understood that as the project evolves, tasks may be revised and may change as more information becomes available throughout the project period.

Evaluation Tasks

In keeping with the data sources and methods identified in the evaluation matrix (refer to Table 1) four major data collection and reporting activities are planned. In general, information will be collected and synthesized on an ongoing basis in order to provide timely information for project management and to support contract reporting requirements. (See Table 2 for an evaluation schedule of the evaluation tasks.)

Task 1. Communicate with Dawn E/PO Team

The mutual sharing of information is an important component in the participatory nature of the evaluation. The evaluator will meet with Dawn team members in order to share information about project implementation as well as the evaluation process. The evaluator will be responsible for presenting formative feedback to the team as it is appropriate and relevant to enhancing the outreach effort. At times, informal interviews may be conducted with team members in order to thoroughly address the evaluation questions.

Task 2. Develop Instruments and Recruit Participants

Multiple instruments and data management mechanisms will be used throughout the project evaluation. Databases will be maintained in order to document Web site statistics, product dissemination, E/PO staff presentations and publications, and other relevant outreach activities. Online surveys will be developed in order to collect feedback from public and educator audiences who use the Dawn E/PO Web site and online materials. Interview and observation guides will be developed to address questions in the evaluation matrix. The interview and observation protocols will be revised as appropriate to reflect changes in project work and evaluation focus. In addition, logic models will be developed and used to illustrate relationships among project goals and activities. These will be revised accordingly to reflect programmatic changes.

Instruments for pilot-and field-testing will be developed or adapted as appropriate. A literature review will be conducted in order to identify extant assessments that measure student learning of space science knowledge and skills. It is preferable that a battery of assessments be used in order to detect any effects of the Dawn E/PO curriculum materials on students in field-test sites. Additionally, a power analyses from past research on supplemental science materials will be conducted in order to determine expected effect sizes[6] for the Dawn E/PO classroom materials.

E/PO team members will identify a small number of classrooms for pilot-testing Dawn E/PO curriculum materials. Sites will most likely be located in southern California and the Denver, Colorado area. Field-test teachers will be identified through existing McREL E/PO development networks, conference and Dawn E/PO Web site announcements, and other recruiting strategies. Control groups for the field testing will be located within the same school or district as treatment groups.

Task 3. Collect and Analyze Data from Multiple Sources

Project plans, task descriptions, e-newsletters, Web site statistics, project materials, and local district documents (from the field-test sites) will be collected and reviewed throughout the outreach process. E/PO team members are responsible for completing, maintaining, and providing access to these internal documents.

With consideration of resource and time allocations, the evaluator will visit a sample of the field-test sites in order to ensure implementation fidelity and to provide data triangulation through classroom observations and teacher interviews. The frequency of site visits may vary according to changing data collection needs during the evaluation process. Data will also be collected from participants who attend conference presentations and professional development trainings. In addition, data from the on-line surveys will be aggregated and reported to E/PO team member to inform product development.

Analyses will be based on evaluation data from project documents, participant interviews, surveys, student assessments, participant feedback forms, and observations from site visits. Analyses of quantitative data will include descriptive and inferential statistics. A process of analytic induction will be used to analyze qualitative data from interviews and observations. A content analysis will be conducted of open-ended responses to survey items. A database will be created to conduct retrieval, coding and management of the data corpus. Both qualitative and quantitative analyses will be conducted, as appropriate.

[6] Effect sizes are a measure of practical significance and, in this case, will indicate the difference in learning between students who use Dawn E/PO materials and those who do not.

Task 4. Report on Findings

Reports for the Dawn E/PO initiative will include the evaluation plan, event-specific data reports, and annual evaluation reports. In addition, oral briefings for formative feedback will be shared with team members, as necessary. Reports will be disseminated to E/PO members and project staff, as requested.

Evaluation Schedule

Table 2: Evaluation Schedule

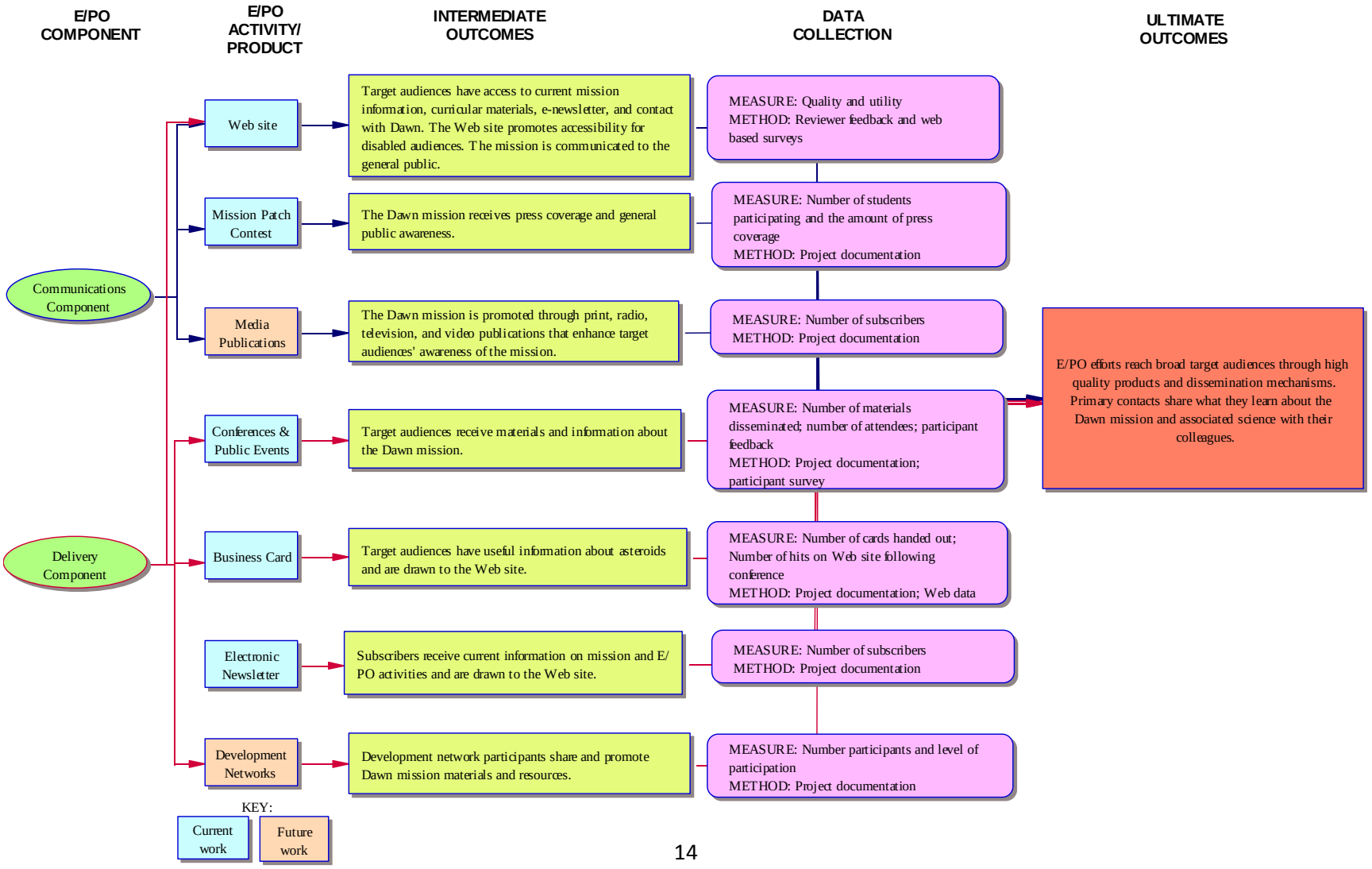
TASK	SCHEDULE	ACTION & RESPONSIBILITY
Task 1. Communicate with Dawn staff		
a. Attend relevant project meetings	Ongoing	The evaluator will meet with Dawn E/PO staff to share information about project implementation and the evaluation process.
b. Distribute evaluation plan	September 2003	
c. Conduct informal interviews with team members	As appropriate	
Task 2. Develop Instruments and Recruit Participants		
a. Conduct literature review & identify assessment instruments	Fall 2003	a.-c. The evaluator will identify, adapt, or develop data collection instruments.
b. Develop and revise Web site evaluation forms	As appropriate	d. The evaluator and project staff will identify & recruit pilot-and field-test participants. Participant consent and Human Subject Review will be conducted as necessary.
c. Develop/modify interest, attitude, and use survey	Fall 2003	e. Interview and observation guides will be developed and revised as appropriate.
d. Recruit participants for pilot- and field testing	Summer/Fall 2003	f. Dawn project staff will work with the evaluator to revise program logic models to reflect programmatic changes.
e. Develop interview and observation guides	As appropriate	
f. Develop and revise logic models	Annually	

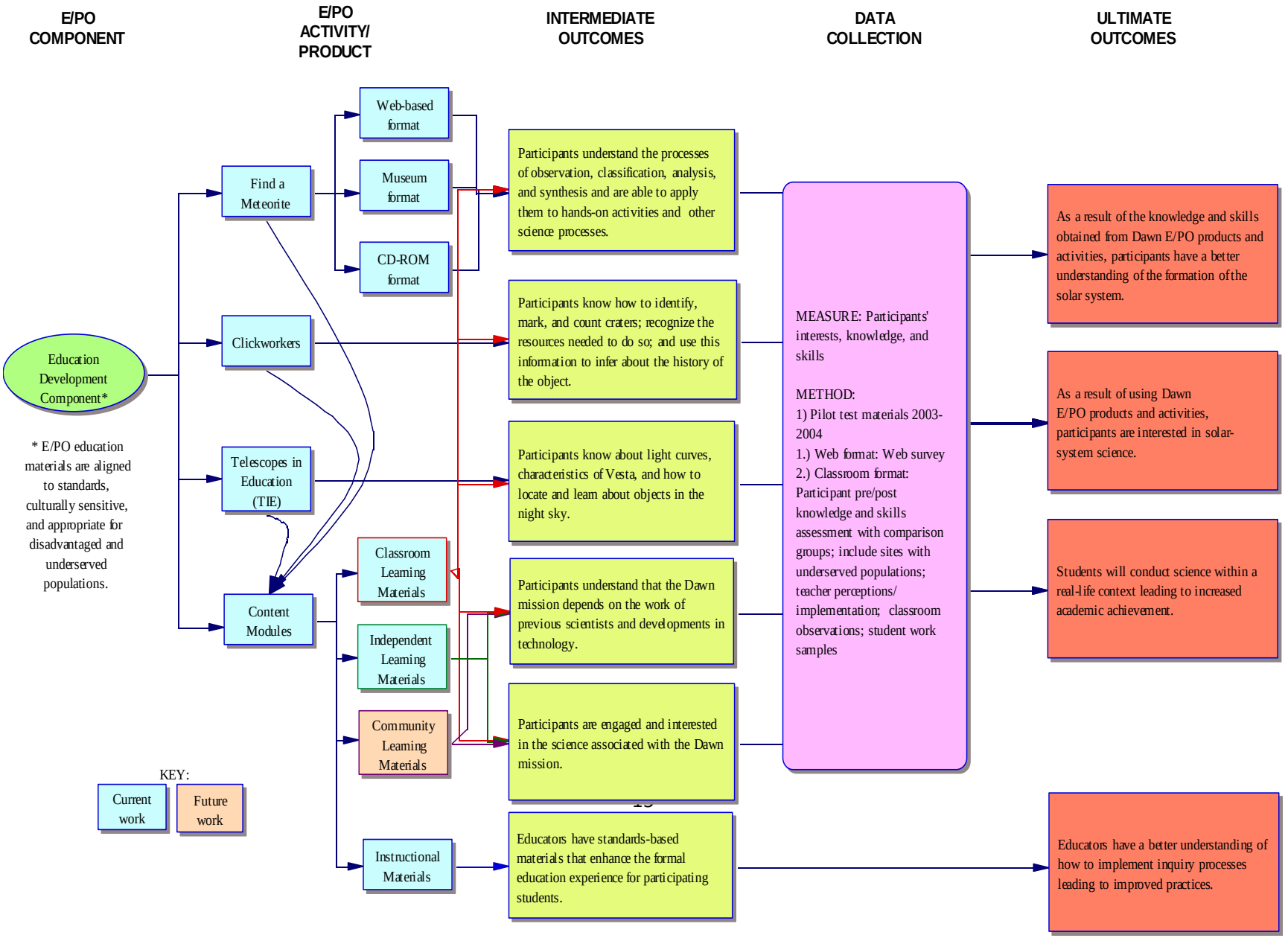
TASK	SCHEDULE	ACTION & RESPONSIBILITY
Task 3. Collect and Analyze Data from Multiple Sources		
a. Review project documents and materials including the e-newsletter, Web site statistics, project/task plans, and Web site resources.	Ongoing	a. Dawn project staff will provide access to relevant internal documents and user information.
b. Education development networks i. Pilot testing ii. Field testing c. Professional development participants d. On-line survey data e. Conference presentations and trainings f. Set up database for data management and analysis g. Data entry	2003-2004 2004-2006 As scheduled Quarterly As appropriate Fall 2003, as appropriate As appropriate	b.-e. The evaluator will visit education development networks to make classroom observations, to interview project participants, as necessary, and to better understand the context of project implementation. The evaluator will also interview a sample of teachers participating in the professional development program. Dawn project staff will collect participant feedback. f.-g. The evaluator will synthesize interview and observation data, survey data, assessment data, and document collection information for analysis.

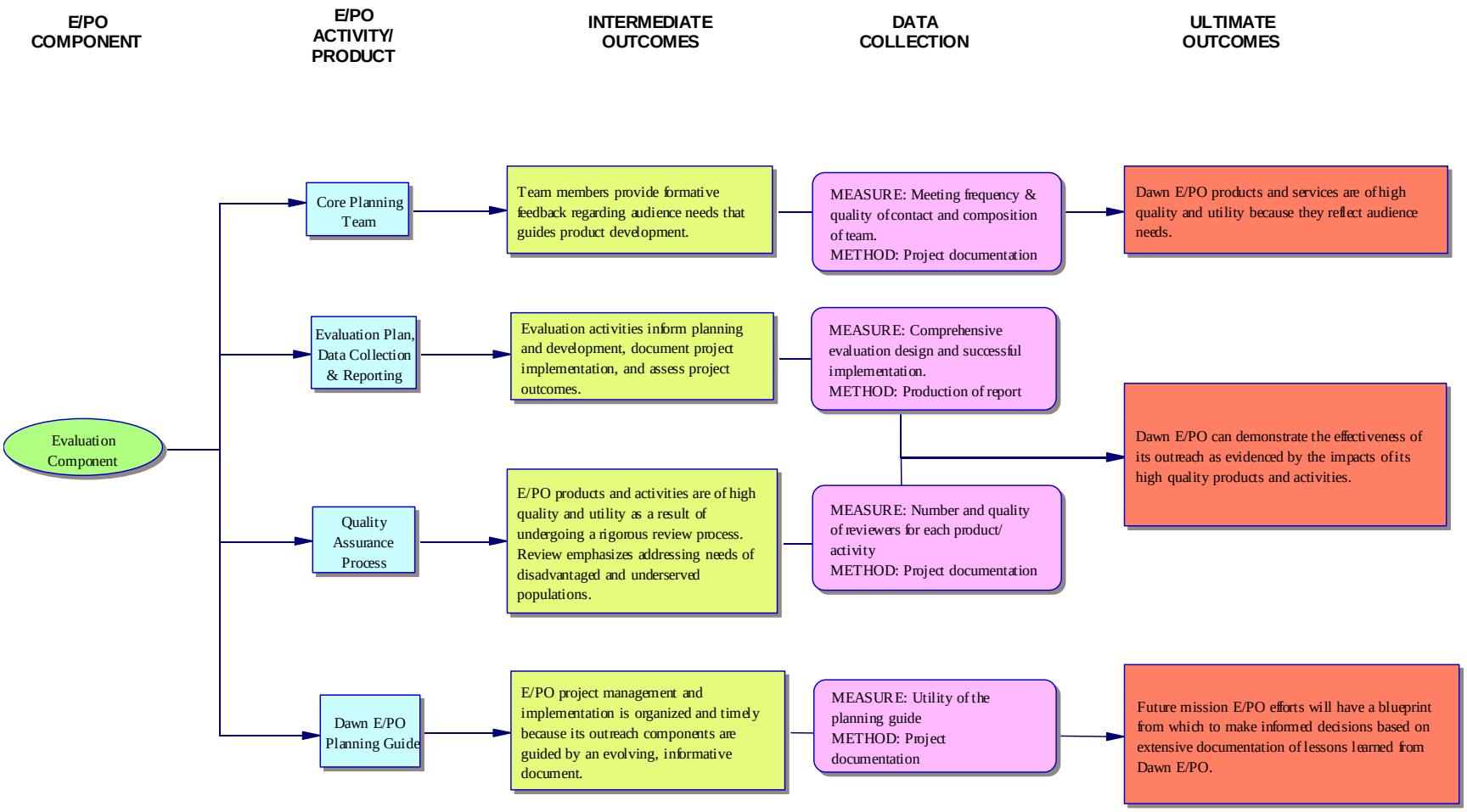
TASK	SCHEDULE	ACTION & RESPONSIBILITY
Task 4. Report on Findings		
a. Formative feedback for team members	As appropriate	The evaluator will report and disseminate findings as appropriate.
b. Event-specific data reports	As appropriate	
c. *Evaluation Plan*	September 2003	
d. *Annual Evaluation Report*	October, annually	

EVALUATION PLAN APPENDIX:

Logic Models for Dawn Education and Public Outreach


E/PO COMPONENT
E/PO ACTIVITY/ PRODUCT
INTERMEDIATE OUTCOMES
DATA COLLECTION
ULTIMATE OUTCOMES
Communications Component
Delivery Component
Web site
Mission Patch Contest
Media Publications
Conferences & Public Events
Business Card
Electronic Newsletter
Development Networks
Target audiences have access to current mission information, curricular materials, e-newsletter, and contact with Dawn. The Web site promotes accessibility for disabled audiences. The mission is communicated to the general public.
The Dawn mission receives press coverage and general public awareness.
The Dawn mission is promoted through print, radio, television, and video publications that enhance target audiences' awareness of the mission.
Target audiences receive materials and information about the Dawn mission.
Target audiences have useful information about asteroids and are drawn to the Web site.
Subscribers receive current information on mission and E/PO activities and are drawn to the Web site.
Development network participants share and promote Dawn mission materials and resources.
MEASURE: Quality and utility
METHOD: Reviewer feedback and web based surveys
MEASURE: Number of students participating and the amount of press coverage
METHOD: Project documentation
MEASURE: Number of subscribers
METHOD: Project documentation
MEASURE: Number of materials disseminated; number of attendees; participant feedback
METHOD: Project documentation; participant survey
MEASURE: Number of cards handed out; Number of hits on Web site following conference
METHOD: Project documentation; Web data
MEASURE: Number of subscribers
METHOD: Project documentation
MEASURE: Number participants and level of participation
METHOD: Project documentation
E/PO efforts reach broad target audiences through high quality products and dissemination mechanisms. Primary contacts share what they learn about the Dawn mission and associated science with their colleagues.
KEY:
Current work
Future work


E/PO COMPONENT
E/PO ACTIVITY/ PRODUCT
INTERMEDIATE OUTCOMES
DATA COLLECTION
ULTIMATE OUTCOMES
Education Development Component*
* E/PO education materials are aligned to standards, culturally sensitive, and appropriate for disadvantaged and underserved populations.
Find a Meteorite
Clickworkers
Telescopes in Education (TIE)
Content Modules
Web-based format
Museum format
CD-ROM format
Classroom Learning Materials
Independent Learning Materials
Community Learning Materials
Instructional Materials
Participants understand the processes of observation, classification, analysis, and synthesis and are able to apply them to hands-on activities and other science processes.
Participants know how to identify, mark, and count craters; recognize the resources needed to do so; and use this information to infer about the history of the object.
Participants know about light curves, characteristics of Vesta, and how to locate and learn about objects in the night sky.
Participants understand that the Dawn mission depends on the work of previous scientists and developments in technology.
Participants are engaged and interested in the science associated with the Dawn mission.
Educators have standards-based materials that enhance the formal education experience for participating students.
MEASURE: Participants' interests, knowledge, and skills
METHOD:
1) Pilot test materials 2003-2004
1.) Web format: Web survey
2.) Classroom format: Participant pre/post knowledge and skills assessment with comparison groups; include sites with underserved populations; teacher perceptions/ implementation; classroom observations; student work samples
As a result of the knowledge and skills obtained from Dawn E/PO products and activities, participants have a better understanding of the formation of the solar system.
As a result of using Dawn E/PO products and activities, participants are interested in solar-system science.
Students will conduct science within a real-life context leading to increased academic achievement.
Educators have a better understanding of how to implement inquiry processes leading to improved practices.
KEY:
Current work
Future work


E/PO COMPONENT
E/PO ACTIVITY/ PRODUCT
INTERMEDIATE OUTCOMES
DATA COLLECTION
ULTIMATE OUTCOMES
Evaluation Component
Core Planning Team
Team members provide formative feedback regarding audience needs that guides product development.
MEASURE: Meeting frequency & quality of contact and composition of team.
METHOD: Project documentation
Dawn E/PO products and services are of high quality and utility because they reflect audience needs.
Evaluation Plan, Data Collection & Reporting
Evaluation activities inform planning and development, document project implementation, and assess project outcomes.
MEASURE: Comprehensive evaluation design and successful implementation.
METHOD: Production of report
Quality Assurance Process
E/PO products and activities are of high quality and utility as a result of undergoing a rigorous review process. Review emphasizes addressing needs of disadvantaged and underserved populations.
MEASURE: Number and quality of reviewers for each product/ activity
METHOD: Project documentation
Dawn E/PO can demonstrate the effectiveness of its outreach as evidenced by the impacts of its high quality products and activities.
Dawn E/PO Planning Guide
E/PO project management and implementation is organized and timely because its outreach components are guided by an evolving, informative document.
MEASURE: Utility of the planning guide
METHOD: Project documentation
Future mission E/PO efforts will have a blueprint from which to make informed decisions based on extensive documentation of lessons learned from Dawn E/PO.

Appendix 2
Educational Standards Report:

Dawn's E/PO team has delivered on its promise to provide standards-based educational materials. Our Content Module #1 potentially addresses the following standards. During Phase C/D, our review process helps us respond to the needs of our audience. At that point, we will identify specific standards correlated to particular products.

Grades 5-8

Science as Inquiry

Understandings about Scientific Inquiry

- Different kinds of questions suggest different kinds of investigations
- Current scientific knowledge and understanding guides scientific investigations
- Mathematics is important in all aspects of scientific inquiry
- Technology used to gather data enhances accuracy and allows scientists to analyze and quantify results of investigations
- Scientific explanation emphasizes evidence
- Science advances through legitimate skepticism
- Scientific investigations sometimes result in new ideas for study

Physical Science

Motions and Forces

- The motion of an object can be described by its position, direction of motion and speed. That motion can be measured and represented on a graph.

Transfer of Energy

- Light interacts with matter by reflection. To see an object, light from that object must enter the eye.

Earth and Space Science

Earth in the Solar System

- The Earth is the third planet from the sun in a system that includes the moon, the sun, eight other planets and their moons, and smaller objects such as asteroids and comets.
- Most objects in the solar system are in regular and predictable motion.

Science and Technology

Understandings about science and technology

- Scientific inquiry and technological design have similarities and differences
- Many different people in different cultures have made and continue to make contributions to science and technology
- Science and technology are reciprocal
- Perfectly designed solutions do not exist

- Technological designs have constraints
- Technological solutions have intended benefits and unintended consequences.

Science in Personal and Social Perspectives

Science and Technology In Society

- Science influences society through its knowledge and world view
- Technology influences society through its products and processes
- Science and technology have advanced through contributions of many different people, in different cultures, at different times in history
- Scientists and engineers work in many different settings…
- Science cannot answer all questions and technology cannot solve all human problems or meet all human needs

History and Nature of Science

Science as a Human Endeavor

- Women and men of various social and ethnic backgrounds…engage in the activities of science, engineering and related fields
- Science requires different abilities, depending on such factors as the field of study and type of inquiry

Nature of Science

- Scientists formulate and test their explanations of nature using observation, experiments, and theoretical and mathematical models.
- In areas where active research is being pursued… it is normal for scientists to differ with one another about the interpretation of the evidence
- It is part of scientific inquiry to evaluate the results of scientific investigations, experiments, observations, theoretical models, and the explanations proposed by other scientists

History of Science

- Many individuals have contributed to the traditions of science
- In historical perspective, science has been practiced by different individuals in different cultures
- Tracing the history of science can show how difficult it was for scientific innovators to break through the accepted ideas of their time to reach the conclusions that we currently take for granted

National Standards Addressed in Dawn Phase B Materials:
From *AAAS Benchmarks for Science Literacy*:
Grades 6-8
The Nature of Science

The Scientific World View

- When similar investigations give different results, the scientific challenge is to judge whether the differences are trivial or significant, and it often takes further studies to decide. Even with similar results, scientists may wait until an investigation has been repeated many times before accepting the results as correct.
- Scientific knowledge is subject to modification as new information challenges prevailing theories and as a new theory leads to looking at old observations in a new way.
- Some scientific knowledge is very old and yet is still applicable today.

Scientific Inquiry

- Scientists differ greatly in what phenomena they study and how they go about their work. Although there is no fixed set of steps that all scientists follow, scientific investigations usually involve the collection of relevant evidence, the use of logical reasoning, and the application of imagination in devising hypotheses and explanations to make sense of the collected evidence.
- What people expect to observe often affects what they actually do observe. Strong beliefs about what should happen in particular circumstances can prevent them from detecting other results. Scientists know about this danger to objectivity and take steps to try and avoid it when designing investigations and examining data. One safeguard is to have different investigators conduct independent studies of the same questions.
- New ideas in science sometimes spring from unexpected findings, and they usually lead to new investigations.

The Scientific Enterprise

- Important contributions to the advancement of science, mathematics, and technology have been made by different kinds of people, in different cultures, at different times.
- No matter who does science and mathematics or invents things, or when or where the do it, the knowledge and technology that result can eventually become available to everyone in the world.
- Scientists are employed by colleges and universities, business and industry, hospitals, and many government agencies. Their places of work include offices, classrooms, laboratories, farms, factories, and natural field settings ranging from space to the ocean floor.
- Computers have become invaluable in science because they speed up and extend people’s ability to collect, store, compile, and analyze data, prepare research reports, and share data and ideas with investigators all over the world

- Accurate record-keeping, openness, and replication are essential for maintaining an investigator's credibility with other scientists and society.

The Nature of Mathematics

Patterns and Relationships

- Usually there is no one right way to solve a mathematical problem; different methods have different advantages and disadvantages.

Mathematics, Science, and Technology

- Mathematics has contributed to progress in science and technology for thousands of years and still continues to do so.
- Mathematics is helpful in almost every kind of human endeavor.
- Mathematics has contributed to progress in science and technology for thousands of years and still continues to do so.

The Nature of Technology

Technology and Science

- Technology is essential to science for such purposes as access to outer space and other remote locations, sample collection and treatment, measurement, data collection and storage, computation, and communication of information.

Issues in Technology

- Throughout history, people have carried out impressive technological feats, some of which would be hard to duplicate today even with modern tools. The purposes served by these achievements have sometimes been practical, sometimes ceremonial.
- Technology has strongly influenced the course of history and continues to do so. It is largely responsible for the great revolutions in agriculture, manufacturing, sanitation and medicine, warfare, transportation, information processing, and communications that have radically changed how people live.
- Societies influence what aspects of technology are developed and how these are used. People control technology (as well as science) and are responsible for its effects.

The Physical Setting

The Universe

Grades 3-5

- Telescopes magnify the appearance of some distance objects in the sky, including the moon and the planets…
- Planets change their position against the background of stars.

Grades 6-8

- Large numbers of chunks of rock orbit the sun.

Grades 9-12

- Increasingly sophisticated technology is used to learn about the universe.
- Motion

Grades 6-8

- Light from the sun is made up of a mixture of many different colors of light. Other things that give off or reflect light have a different mix of colors.
- Something can be "seen when light waves emitted or reflected by it enter the eye.
- Human eyes respond to only a narrow range of wavelengths of electromagnetic radiation.
- The Mathematical World
- Symbolic Relationships
- Graphs can show a variety or possible relationships between two variables.
  Shapes
- The graphic display of numbers may help to shown patterns. Such patterns sometimes can be used to make predictions about the phenomena being graphed.

Historical Perspectives

Displacing the Earth from the Center of the Universe

- In the 16th century, a Polish astronomer named Copernicus suggested that all those same motions (described by Ptolemy) could be explained by imagining that the earth was turning around once a day and orbiting around the sun once a year.
- Johannes Kepler, a German astronomer who lived at about the same time as Galileo, showed mathematically that Copernicus' idea of a sun centered system worked well if uniform circular motion was replaced with uneven (but predictable) motion along off-center ellipses.
- Using the newly invented telescope to study the sky, Galileo made many discoveries that supported the ideas of Copernicus…

National Standards Addressed in Dawn Phase B Materials:
From National Council of Teachers of Mathematics, NCTM's *Principles and Standards for School Mathematics*

Grades 6-8

Algebra

Understands patterns, relations, and functions

- Represent, analyze and generalize a variety of patterns with tables, graphs, words and, when possible, symbolic rules.
- Use mathematical models to represent and understand quantitative relationships

- Model and solve contextualized problems using various representations such as graphs, tables, and equations.

Represent and analyze mathematical situations and structures using algebraic symbols

- Use symbolic algebra to represent situations and to solve problems, especially those that involve linear relationships.

Use mathematical models to represent and understand quantitative relationships

- Model and solve contextualized problems using various representations such as graphs, tables, and equations.

Analyze change in various contexts

- Use graphs to analyze the nature of changes in quantities in linear relationships

National Standards Addressed in Dawn Phase B Materials:
From McREL's *Content Knowledge: A Compendium of Standards for K-12 Education*
Grades 6-8
History

Historical Understanding

Understands and knows how to analyze chronological relationships and patterns.

- Knows how to construct and interpret multiple tier timelines.

Grades 6-8
English Language Arts

Uses grammatical and mechanical conventions in written compositions

- Gathers and uses information for research purposes

Uses reading skills and strategies to understand and interpret a variety of informational texts

- Summarizes and paraphrases information in texts

Uses listening and speaking strategies for different purposes

- Makes oral presentations to the class

Appendix 3 – Dawn Guide (projected in FY 06, i.e. what we said we would do)

Deliverables Phase E:

Our audience, at launch, will have access to Find a Meteorite, Telescopes in Education, Clickworkers, and Content Modules one and two. These products are developed to include learner guides that are appropriate for a wide range of ages and venues making them suitable for formal, informal and public education. We continue this practice in Phase E deliverables.

Phase E deliverables are of three types. We have materials and activities that are maintained, activities and products that are produced, and activities and products that are reviewed and revised.

The length of this mission provides wonderful opportunities for educational as well as solar system origins research. We work with our evaluation team to anticipate and exploit any opportunities for providing summative evaluations on the effectiveness of our materials. The results of these studies are made available to the broader educational community and NASA E/PO efforts.

Maintained:

1. quarterly updates of web site
2. quarterly e-Newsletter
3. workshops and conferences
1. Find a Meteorite
2. Telescopes in Education
3. Clickworkers
4. FAQ page

Delivered by Arrival at Vesta:

1. A content module on mission instrumentation
2. A content module about theories of the origin of the solar system
3. A content module about data analysis
4. Electronic Field Trip
5. Planetarium shows
6. Museum displays
7. Solar System Ambassadors (Vesta Speaker's Kits)

Materials Reviewed and Revised:

1. Review of content module on the History of asteroid discovery up to the time of the Dawn mission
2. Review of content module on Ion Propulsion
3. The Telescope in Education (TIE) review
4. Review of FAM
5. Review of Clickworkers/Cratering activities
6. Mission video review

Content Modules:

Content modules on "Mission Instrumentation" and "Theories on the Origins of the Solar System" are worked on during year '08. The final content module on "Data Analysis, Anticipation and Expectation" is started in year '10.

Summative studies on the effectiveness of content modules 1 and 2 will be completed by '10 and any necessary revisions made. Summative studies are done on content modules 3, 4, and 5 in year '14. Particular attention is paid to the effectiveness of our learning tools and the Dawn Learning Cycle.

Action Items/Assignments	Person	Stated Benefits/Outcomes	Identified Measurables	Delivery Date
Content Module 3 Planning/Development	McREL, JW, LM	Informs about mission instrumentation	1st Draft	7/29/05
Content Module 4 Planning/Development	McREL, JW, LM	Theories of Solar System	1st Draft	'08
Content Module 5 Planning/Development	McREL, JW, LM	Data Analysis	1st Draft	'10

Solar System Ambassadors:

As we approach Vesta, Dawn's E/PO makes use of the highly successful Solar System Ambassadors Program, run by Kay Ferrari at JPL.

Action Items/Assignments	Person	Stated Benefits/Outcomes	Identified Measurables	Delivery Date
Speakers Kit Assembly	McREL, JW, LM	Material available to all partners to use in their community	Completion of the kit to include: mission identifier graphics,	'10

		outreach efforts.	business card, fact sheet, evaluation materials, templates for PowerPoint presentation.	
Speakers Kit Review Revision	McREL, JW, LM	See above	Reports from mission partners on outreach activities and their use of the Speakers Kit.	'10
Solar System Ambassadors Deployed	JPL	JPL ambassadors communicate the excitement of the Dawn mission to their local communities.	Reports from mission partners on outreach activities and their use of the Speakers Kit.	'11

Website:

We anticipate two complete redevelopments of our web pages during phase E. We will accommodate new technologies and software so that our web site provides an effective source of Dawn mission information and E/PO products.

In 2008 we will provide images of the first asteroid flyby. Additional money has been budgeted during the flyby year and the arrival at Vesta.

Action Items/Assignments	Person	Stated Benefits/Outcomes	Identified Measurables	Delivery Date
Updates as needed, Quarterly Updates minimum	McREL	Provides access to 1. current mission information, 2. curricular materials, 3. archives of eNewsletter, 4. contact Dawn,	Feedback from reviewers and users at conferences and web based surveys	Quarterly 10/1/06 – 9/29/14

Electronic Newsletter:

During phase E, we continue to publish a quarterly e-Newsletter. Teachers, students, and the general public may sign up to receive the newsletter at our website. The Dawn e-Newsletter will

be announced in all e-Newsletters currently distributed by McREL and at all conferences and workshops.

Action Items/Assignments	Person	Stated Benefits/Outcomes	Identified Measurables	Delivery Date
Electronic Newsletter	McREL	1. Provides current information on Mission and Mission E/PO activities 2. Draws to web page	Number of subscribers	Quarterly 10/1/06 – 9/29/14

Find a Meteorite (FAM):

FAM goes through a summative review in '07. From this review, necessary revisions are made. Workshops are developed for formal/informal educator training.

Action Items/Assignments	Person	Stated Benefits/Outcomes	Identified Measurables	Delivery Date
FAM Summative Review	McREL	Assures that materials are in line with formal/informal ed requirements	Effectiveness in addressing OSS goals and guidelines for E/PO	'07
FAM Revision and re-release	McREL, JW, LM	Assures quality product	Revised Document	'07

Telescopes in Education (TIE):

TIE goes through a summative review in '07. From this review, necessary revisions are made. Workshops are developed for formal/informal educator training.

Action Items/Assignments	Person	Stated Benefits/Outcomes	Identified Measurables	Delivery Date
TIE: Summative Review	McREL	Assures that materials are in line with educator requirements	Effectiveness in addressing OSS goals and guidelines for	'07

			E/PO	
TIE: Revision and re-release	McREL, JW, LM	Assures that materials are in line with educator requirements	Revised document	‘07

Clickworkers (CW):
Clickworkers and its related cratering activities undergo a summative review in ’07. Workshops are developed for formal/informal educator training. Additional cratering images are included in the data base.

Video/Electronic Field Trip:
A video documentary and electronic field trip are completed in phase C/D. In Phase E, we produce a video that provides a summation of the mission and any findings known at the time of videoing. This video might include an electronic “field trip” to the asteroid belt and to Vesta.

Action Items/Assignments	Person	Stated Benefits/Outcomes	Identified Measurables	Delivery Date
Mission Summary Video and electronic field trip	McREL, LM, JW	Provides summary of the mission and results in visual format	Effectiveness in addressing OSS goals and guidelines for E/PO	‘14

Museums/Planetaria:
We work with Museums to provide Find a Meteorite as a museum display activity. We also provide curricular materials and activities packets for group presentations at museums. Technical assistance is given to help develop displays featuring the Dawn Mission. We support the development of planetarium shows that inform people on the origins of our solar system.

Core Planning Team (CPT):
Appropriate conferences are identified in the phase E Dawn Guide.

Conferences and Workshops:
Conferences and workshops are carefully planned by the Management Team to correspond to conferences McREL is already attending so that leveraging can occur whenever possible. These conferences and workshops are identified in the phase E Dawn Guide.

Appendix 4 – DAWN E/PO ANNOTATED PRODUCT LIST

Formal Education – *designed with students and teachers in mind*
http://dawn.jpl.nasa.gov/DawnClassrooms/index.asp

- Content Modules
  - **Looking from Afar –** History and Discovery of Asteroids *Grades 5-8*
    Learners will explore scientific discoveries and the technologies as a sequence of events that led eventually to the Dawn mission. This standards-aligned module is organized around a **learning cycle** and engages students in a number of experiences in order for the teacher to activate students' prior knowledge, assess student conceptual understanding in order to inform instruction.
    - **Briefing**
      - **Journey to the Beginning of the Solar System:** Provides students with background information on the Dawn mission.
      - **Briefing Slide Show Pdf: Dawn Spacecraft Poised for Flight to Asteroid Belt:** Overview of the Dawn mission: 1) A fictitious news article begins with the launch of the Dawn spacecraft in 2006. 2) Travel to the asteroid belt to study Vesta and Ceres. 3) Significant role that asteroids play in revealing early solar system information.
    - **Exploration**
      - **Where the Journey Began:** Eight short readings trace the history of asteroid discovery and characterization from the time of Ptolemy (85-150 AD) to the present time.
      - **Flash Back into Time:** interactive to help students gain overview of the history and discovery of asteroids and how Dawn's mission fits into that, with references to the eight reading associated with this section.
        - **Thinking Outside the Box**
        - **Between Jupiter and Mars I, Place a Planet**
        - **Seeing Faraway Things as Though Nearby**
        - **It Was a Dark and Starry Night**
        - **The Lost is Found**
        - **Astronomical Serendipity**
        - **What Can You See With a Telescope?**

♦ **I Can See You More Clearly Now**

- **Development**
  - **Modeling Asteroids**- contains hands-on activities that can be used to help students understand what astronomers in the historical readings of the Exploration Section were experiencing as they studied asteroids from Earth.
  - **Patterns in the Sky-** Students look at planetary distance information and use algebra to "discover" a gap between Mars and Jupiter.
  - **In Search Of …** - Students use a modern starchart to find a missing planet?
  - **How Bright Are You?** - Students graph the brightness of asteroids and asteroid size versus their dates of discovery.
  - **Seeing Circles** - Students use different objects to learn about and model albedo.
  - **Where Are You?** - Students develop a model of asteroid diameters using mathematics and food.
  - **Modeling in 3-D** - Students experience how models can be made to represent objects in space.
- Interaction Synthesis
  - **Communicating Connections** Students communicate and synthesize what they have learned about the interrelatedness of science, technology, and relevant historical/political events.
- Assessment
  - Mystery Asteroid - Students apply their new knowledge and skills by making observations, inferences, and conclusions about a "mystery asteroid." The assessment provides students with a Hubble Space Telescope picture of the mysterious small body and then later presents some facts, Teacher can use students' responses to the assessment questions to evaluate their understanding of the module content.

➢ **How Do We Get Closer? – Structure and Properties of Matter: Ion Propulsion**
Grades 9-12

This standards aligned module is intended to engage students and the interested public in the propulsion technology that is necessary for Dawn to complete its mission. As students interact with this module, they will gain an understanding of : charges and relative charge , momentum and frames of reference , ionization and plasma , how an ion propulsion

system works , and experiment with designing an ion engine to determine optimal conditions using an interactive simulation.

- Briefing
  - How Do We Get There?
    Just like a mission briefing for the press, the purpose of this section of the module is to provide students with some background information about the Dawn mission and the need for a spacecraft with ion propulsion in order to meet mission objectives.
    - Timeline (PDF 44k) Student Information Sheet
      Ion Propulsion Story Mapping History Frame (PDF 44k) Student Activity
      How Do We Get There? PowerPoint (PPT 6.4 Mb)
- Exploration
  - **We Need a Push**
    This portion ion propulsion concept development focuses on the basic science necessary for understanding the design and operation of an ion propulsion engine.
    - Charges - Student Reading
      Pushing with Plasma - Student Reading
      Attractive and Repulsive Forces - Student Activity
      Attractive and Repulsive Forces - Student Reporting Sheet
      Positive and Negative Charges - Interactive Simulation
- Development
  - **Where Are We?**
    Students will develop an understanding that motion is relative by reading the text "Frames of Reference." As a follow-up to the reading, engage students in a writing-to-learn strategy that can help students understand how motion depends on specific frames of reference, as they are asked to assume a specific frame of reference and describe motion in relation to multiple perspectives.
    - Frames of Reference - Student Reading
      Relative Motion RAFT Writing Activity - Student Activity
      Powered by the Sun - Student Reading
- Interaction Synthesis
  - Getting Charged Up

Students will follow a single xenon atom as it travels through an ion propulsion engine, putting together the scientific concepts that play a part in moving the Dawn spacecraft.

- A Trip Through An Ion Propulsion Engine - Student Reading
- The Trip of One Xenon Atom Through an Ion Engine - PowerPoint

- Assessment
  - **Design an Ion Engine**
    Students apply the background information from this module to determine what Plate Location settings and what Plate Charge produces the most thrust for the engine.

➢ **How Do We "Look" When We Get There? - Interactions of Energy & Matter**: Dawn Instrumentation
The Dawn spacecraft contains instruments that will provide new answers to questions about the formation and evolution of the early solar system. It will consist of four interactives elucidating Dawn's major instrumentation with accompanying educational support.

- Briefing
  - **CSI Dawn**
    - In this activity, a crime was committed on the sandy shore of a lake at a local park. Your students will act as members of a crime scene investigation team that has taken a soil sample while investigating what is thought to be the scene of a crime.
- Exploration
  - **Instrument Exploration**
    - Exploration is designed to help students understand more about how the each of the instruments (FC, GRaND, VIR) aboard the Dawn Spacecraft operate and what they will help us "see" when the spacecraft reaches Ceres and Vesta
- Development
  - **Gravity Estimation**
    - Students study simulated data from locations within the orbits in which the spacecraft changes velocities.
- Interaction Synthesis

- **Mineral Identification**
  - ♦ Students are guided through the analytical process that Dawn scientists will use to determine the mineral content of the surfaces of Vesta and Ceres from the experimental data collected by the instrument payload onboard the Dawn spacecraft.

▪ Assessment

- **Concept Maps**
  - ♦ This activity is designed to assess your students' understanding of the matter and energy interactions and relationships.

➢ **Origins of the Solar System –** What Questions Might Vesta and Ceres Answer?
In Active Development

➢ **Looking Up Close –** What Did We Find: Data Analysis
In Development

Informal Education – *designed for individuals; informal education sites, such as after school programs, museums, and science camps; and the general public. Appropriate for the classroom as well.*
http://dawn.jpl.nasa.gov/education/index.asp

❖ Activities

➢ Dawn Kids *Grades K-8*
A menu of activities with application in elementary and middle school.

▪ Join the Vesta Exploration – designed for independent learners as well as informal education settings
- Modeling Vesta in 3-D
- Vesta Flipbook

▪ Everyone Loves a Story
- "Aster's Hoity-Toity Belt"
- "Professor Starr's Dream Trip"
- Use Stories in the Classroom

▪ Construct Your Own Dawn Spacecraft Model
▪ Fun Downloadable Activities

- Dawn Board Game
- Dawn Patch Kit
- Puzzles and Crosswords
- Make Your Own Asteroid… Belt!

➢ Dwarf Planet: **A New Way of Thinking about an Old Solar System**
Grades 5-8

This activity utilizes a researched-based, instructional strategy called direct vocabulary instruction to help students understand the new definitions of planet and dwarf planet.

- **Examples in the Evolution of Language**
- **Podcasts from Mark Sykes**
- **Great Planet Debate** - An educator's workshop was held on August 16, 2008 to provide a forum on how the planet debate can be used to spark scientific inquiry in the classroom.

➢ Career Connections *Grades 5-12*

All kinds of people work on the Dawn project. In addition to providing information about the people of the Dawn mission, one purpose of this careers microsite is to explain many types of careers that go into supporting the work of any NASA mission.

- Dawn's Career Connections Activity - Launch a career investigation in your middle or high school classroom
  - Companion Matrix
    Dawn Profile
    Resume Template
    My Career Objective Sheet
    Interviews & Features
    JPL Career Launch
    Consider a Career in Aerospace poster

➢ **Potato Light Curves** *Grades 5-8*

➢ **Getting a Feel for Gravity** *Grades 5-12*

❖ **Tools**

➢ **Find a Meteorite Interactive** *Grades 5-8*

Learn how meteorites offer clues to unlocking the mysteries of the asteroid belt

- **Ion Engine Interactive** *Grades 5-12*
  Ion Engines use electric fields instead of chemical reactions for power. Ion Engines tend to be much less powerful than engines fueled by chemical reactions, but they are so efficient, they can last for years before running out of fuel. This interactive helps students understand how an ion engine works.

- GRAnD Interactive: *Grades 9-adult*
  The Gamma Ray and Neutron Detector (GRaND) instrument interactive illustrates how scientists learn about the composition of an asteroid by studying energy and neutrons that emanate from it.

- VIR Interactive *Grades 9-adult*
  The Visible and Infrared Spectrometer interactive shows how light enters and moves through the telescope in VIR and is split into component parts in the spectrometer. A 3D data cube then illustrates the diverse and descriptive data this instrument is capable of gathering.

- **Amateur Astronomers** ***All ages***
  Originally put together to support NASA's Discovery mission *Deep Impact*, the AOP is continuing and expanding. We are observing the asteroids Vesta and Ceres in support of the NASA Discovery mission *Dawn* and comet Hartley 2 in support of *EPOXI*.

- **Clickworkers** ***Grade 5 - adult***
  In preparation for critically examining the images of Vesta and Ceres that will be received from the Dawn spacecraft, individuals can count and measure craters using data obtained from the Near Earth Asteroid Rendezvous NEAR spacecraft of asteroid Eros and Mars surface images from Mars Global Surveyor.

❖ **Resources**

Where is Dawn? ***All ages***

Simulated Images of Dawn in its trajectory to the main asteroid belt in relation to various other inner solar system bodies - updated every 2 hours

- **Dawn Dictionary** ***All ages***

  An annotated, visual and audio dictionary of scientific terms used throughout Dawn's education materials

- **Multimedia** ***All ages***
  - **Videos/Audio**

    Enjoy mission-related videos, audio clips, podcasts and animated shorts
    - **Dawn Movie – offers context and goals for the Dawn Mission, narrated by Leonard Nemoy**
    - **Podcasts**
      - Cratering
        What Makes a Planet?
        Dawn Framing Camera
        Education Overview
  - **Image Galleries**

    View image galleries depicting facets of the Dawn mission and spacecraft
  - **Mission Art** - Access artwork depicting various aspects of the Dawn mission
- Distributable materials: ***All ages***
  - Dawn Fact Sheet, Dawn bookmark, Dawn poster calendar, Dawn stickers